COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF INTERNAL AFFAIRS

Thomas A. Logue, Secretary.

TOPOGRAPHIC AND GEOLOGIC SURVEY

George H. Ashley, State Geologist.

Foreword.

This bulletin was originally issued April 2, 1938 as Bulletin 93 of the Survey's mimeograph series. It has long been out of print. Recently certain leading younger stratigraphers have requested that it be reprinted so as to be available to them. It is reproduced exactly as originally issued except for the Foreword and typographic corrections. G.H.A.

T H E C A N A D I A N S Y S T E M

(Technical Bulletin)

By George H. Ashley.

When, in the course of human events, it becomes necessary for one organization to depart from the practice of other similar organizations, a decent respect to the opinions of mankind requires that they should declare the causes which impel separate action (apologies to J.H.).

Lest it be thought by some that the action to be set forth has been hasty, or perhaps ill-advised, let it be stated:

(1) With the organization of the present Geological Survey of the Commonwealth of Pennsylvania and the installation of its present director it was distinctly stated by those to whose efforts its existence was due that the Survey was to be a "free and independent organization, cooperating with but not subservient to other similar organizations," and that, while it might not equal some others in size, it was to be second to none in the world in quality of work and independence of spirit, as befitted the great Commonwealth it was created to serve.

(2) In the spirit of that declaration the present head of the Geological Survey of Pennsylvania for eight years has been studying the subject of the stratigraphic column to be used in the forthcoming reports of that Survey. The results of this study have repeatedly been sent to many competent geologists and a large volume of criticism and comment, mostly constructive, has been received.

(3) The Geological Survey of Pennsylvania would greatly have preferred that the problems here set forth be first considered by a competent committee of open-minded geologists, and we would have willingly pledged ourselves to abide by the conclusions of such a body of our peers. To that end a formal proposal was made to the council of the Geological Society of America as the most competent and representative body in our profession, petitioning that they would themselves consider or would present for consideration by the Society as a whole, the organization of a representative committee to study and report on the subject of unity of stratigraphic nomenclature. The council in its wisdom refused to sponsor the action for which request had been made, and did so in a way to leave no hope for more favorable action at a later date. We were therefore compelled, against our wish, to declare our independence and to set ourselves steadfastly to pursue our course in accordance with the dictatos of our own reason.

Let us, therefore, declare the causes that impel us to this separate action.

(1) Be it noted that in these United States the foundation of our stratigraphic nomenclature is the "formation." Unfortunately the formation is not a stratigraphic unit and it was never intended to be. It is a cartographic unit, was so defined originally, and it is proposed so to use it in the publications of the Pennsylvania Geological Survey. Formation, as a geological term, has no time signifioance. It may be applied to a single bed of rock representing deposition during the minutest part of a period, or it may be applied to a succession of rocks covering deposition during two or more periods. It has, therefore, and obviously, no time value. Likewise, if a group be a succession of formations - which have no time equivalence - the group also can have no time significance. It is proposed therefore to use the term formation in its original sense as a cartographic unit without time significance. It is, however, proposed to give the term "group" definite time significance as a definite part of a series representing a definite part of an epoch of time, and to use "members" and "beds" for the parts of a group.

(2) We hold it to be true and self-evident that time is and has been continuous and that any true unit or measure of time must remain the same for and during any part of time, that is, a "period" treated as a unit or measure of time cannot and may not be of variable length; provided: that where direct evidence for dividing any past time into periods or other subdivisions is meager the division must be made on all the evidence obtainable. The aim of such subdivision is and always must be to arrive at divisions of time as nearly equal as can be made.

(3) Our present subdivisions of time and of the rock succession are based on local studies made in the infancy of the science. As our knowledge of earth history has grown it has become increasingly evident that the "periods" of the earlier days were of quite unequal length, and to that extent failed to meet the conditions of true time units. To correct in some measure this obvious maladjustment there has been in recent years a marked tendency among leading independent workers to subdivide some of the longer periods into two or three periods. Recently the United States Geological Survey published a bulletin and chart by Miss Wilmarth[1] which reveals how far this subdivision has gone and shows that in the division of post-Ordovician time there is coming to be practically unanimous agreement among independent workers the world over. We in the Pennsylvania Geological Survey believe that the subdivisions now most frequently made by independent workers are probably the best that can be made with present knowledge, and we propose to adopt these subdivisions as shown in the following table, based on U. S. Geological Survey Bulletin 769. In reaching this conclusion weight has been given to five factors: (a) thickness or volume of strata the world over (see study of early Paleozoic given beyond as an example of the kind of study here referred to); (b) nature of rock, as affecting probable rate of deposition; (c) continental movements; (d) life changes;

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[1] Wilmarth, M. Grace, The geologic time classification of the United States Geological Survey compared with other classifications: U. S. Geol. Surv. Bull. 769, pp. 135, 1925.

(e) present or probable subdivision into units of smaller rank. Of these factors, thickness or volume of strata has been given first consideration.

POST-ORDOVICIAN GEOLOGIC TIME CLASSIFICATIONS

U.S.G.S. 1890	GEIKIE 1903	DE LAPPARENT 1906	CHAMBERLIN & SALISBURY 1906	HAUG 1911	ULRICH 1914	GRABAU 1921	SCHUCHERT 1924	PENNA. GEOL. SURVEY 1928
QUATERNARY	POST-GLACIAL	PLEISTOCENE	PRESENT	QUATERNARY	NEOGENIC	RECENT	RECENT	QUATERNARY
	GLACIAL		PLEISTOCENE			PLEISTOCENE	NEOGENE	
TERTIARY	PLIOCENE	NEOGENE	PLIOCENE	NEOGENE		NEOGENE		NEOGENE
	MIOCENE		MIOCENE					
	OLIGOCENE	EOGENE	OLIGOCENE	NUMMULITIC	EOGENIC	EOGENE	PALEOGENE	PALEOGENE
	EOCENE		EOCENE					
CRETACEOUS	CRETACEOUS	CRETACEOUS	CRETACEOUS	CRETACEOUS	CRETACEOUS	UPPER CRETACEOUS	UPPER CRETACEOUS	UPPER CRETACEOUS
			COMANCHIAN		COMANCHIAN	LOWER CRETACEOUS	LOWER CRETACEOUS	LOWER CRETACEOUS
JURASSIC	JURASSIC	JURASSIC	JURASSIC	JURASSIC	JURASSIC	JURASSIC	JURASSIC	JURASSIC
TRIASSIC	TRIASSIC	TRIASSIC	TRIASSIC	TRIASSIC	TRIASSIC	TRIASSIC	TRIASSIC	TRIASSIC
CARBONIFEROUS	PERMIAN	PERMIAN	PERMIAN	ANTHRACOLITIC	PENNSYLVANIAN	PERMIAN	PERMIAN	PERMIAN
	CARBONIFEROUS	CARBONIFEROUS	PENNSYLVANIAN			PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN
			MISSISSIPPIAN		TENNESSIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN
					WAVERLYAN			
DEVONIAN	DEVONIAN	DEVONIAN	DEVONIAN	DEVONIAN	DEVONIAN	DEVONIAN	DEVONIAN	DEVONIAN
SILURIAN	SILURIAN	SILURIAN	SILURIAN	SILURIAN	SILURIAN	SILURIAN	SILURIAN	SILURIAN
ORDOVICIAN								

The abovo table should make clear that in so far as tho post-Ordovician periods and systems are concerned, the Pennsylvania Geological Survey has placed itself squarely in accord with tho modern trend of geologic time subdivisions.

(4) From time to time in the past geologists have essayed to estimate the time equivalence of the various systems of rocks as commonly rocognized. Tho average of a number of these estimates[2] based on Silurian time as one, shows that in the estimation of those geologists the several rock systems given above, as adopted for use by the Ponnsylvania Geological Survey, arc of approximately the same length. With one exception (Devonian) none exceeds the Silurian in length by more than 9 percent, and none falls short of the Silurian in length by more than 16 percent. Theso same estimates give an average for Ordovician of 2.14 and for Cambrian of 2.08. In other words, in thoir estimation these two systems are cach practically twice as long as tho post-Ordovician systems listed above. Obviously as they stand these two systems represent longer spans of time than the others, and, if they become true measures of time, must be subdivided.

The only serious attempt to further subdivide the time represented by the Lower Paleozoic rocks has been by Ulrich, who has proposed that the rocks of Ozarkian age and possibly those of Beekmantown age should be separated out and be known as tho Ozarkian and the Canadian systems.

Our study of this problem has failed to convince us that either the Ozark or Beekmantown rocks are of systemic value. On the other hand these studies suggest that a way out may be found by reviving the old term Canadian in its original significance, using Ozark and Beekmantown as two of the series, and a rostricted Chazy, in accordanco with the original dcfinition, as the third series.

Canadian was originally defined by Dana[3] in 1874:

"The fact of the existenco of an important Lower Silurian formation in Canada, near Quebec, abounding in fossils, and of about the age of the Calciferous. sand-rock and the Chazy limestone, is mentioned in the first edition of this work, as one of the discovories of the Canadian Geological Survey, under Sir William Logan. The Reports of the Survey point out the close relations in fossils of the Calciferous sand-rock, Quebec group, and Chazy, and their rather wide separation from the overlying Tronton limestone, showing that they ropresent, naturally, a distinct period in the Lower Silurian era. This is called the Canadian, because the rocks are well displayed in Canada, and there the most important part of the facts respecting it were first brought to light".

Again in 1876 the three periods were set forth again by Dana[4] as follows:

Lower Silurian
- Tronton period:
  - Cincinnati
  - Utica
  - Trenton
- Canadian period:
  - Chazy epoch (Chazy limestone of New York, Canada etc. Part of the crystalline limestone of the Green Mountains in Vermont and to the south).
  - Quebec epoch. (Lévis formation, Canada, noar Quebec; Taconic slates of Green Mountains; shales, limestones and sandstones, Newfoundland. Part of the Knox group, Tonnessee).
  - Calciferous epoch. (Calciferous sand-rock in New York. Lower Magnesian limestone of the Mississippi valley; St. Peters sandstone of Wisconsin and Illinois; Knox sandstone, East Tennessee; thick limestones (part of the so-called Quebec group) of Newfoundland).
- Primordial or Cambrian period:
  - Potsdam
  - Acadian

Archean period.

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2 Williams, Schuchert, Solus, Goodohild, Barrell.

3 Dana, J.D., Amer. Jour. Sci., 3d ser., vol. 8, p.214, 1874.

4 Dana, J.D., Manual of geology, 2d ed., pp. 142, 163, 182, 1876.

"The rocks of the extensive Quobec group were first distinguished and described in Canada by Canadian geologists, and all the subdivisions are well represented there; hence the period is named the Canadian".

The "Calciferous" of Dana is today recognized as the Beekmantown.[5] The Quebec group of Logan, 5,025 feet thick, as given in his original section[5], which obviously formed the backbone of Dana's Canadian system, has since been found to be partly of Ordovician age and partly of Cambrian age as those terms are most generally used today. The upper part is now described as the Lévis beds and correlated with the Aronig of Great Britain (which is correlated with the Beekmantown of New York) and with the overlying Llandeilo zone of Great Britain extending up into the Chazy of New York.

The lower part of the former Quobec group is now called the Sillery. These lower rocks, said to be 5,000 to 6,000 feet thick, and clearly included in Dana's original definition of the Canadian system, are now correlated with the lower Beekmantown and the underlying "Upper Cambrian" or Tremodoc which Ulrich correlates with the Ozark in America. The reference of Ozark rocks to the Canadian system seems therefore to be fully in accord with the original definition. Furthermore, in describing the distribution of the Quebec rocks Dana[6] says: "The Quebec group in Tennessee about Knoxville includes the shales and dolomites of the Knox group of Safford." The Lower Knox is today correlated with the Ozark.

Before defining the proposed revived Canadian system it is necessary to redefine and restrict Chazy to its original application, and to show that, as judged by thickness and body of rocks involved, Ozark is not of systemic value. When treated as series Chazy, Beekmantown and Ozark are of practically the same order stratigraphically as the other series composing the restricted Cambrian and Ordovician, and if we use thickness or body of rocks as our determining criteria, the separation of the Canadian as a system as here proposed leads to a fairly orderly and well balanced subdivision of the rocks.

The Chazy of New York as originally named consists of the Valcour limestone at the top, the Crown Point limestone, and the Day Point limestone, having a maximum thickness of 800 feet in that State. It has since been determined that between these rocks and the Lowville limestone, at the base of the Mohawk series, is a body of rocks that reaches a thickness of 8,700 feet in eastern Tennessee and 1,300 feet in southwest Virginia. These Ulrich has called the Blount group and has thrown into the Chazy series. The great thickness of these rocks in east Tennessee suggests that the Blount group may be of series value, and instead of being included with the original Chazy of New York in an extended Chazy may be treated as a series of equal rank to the Chazy (restricted) and coming next in order in time. If then, following Dana, the Chazy (restricted) be made the uppermost series in the Canadian system, the Blount may be considered the equivalent of the Lower Ordovician.

We are unconvinced that the Ozark rocks are of systemic order. The following table shows the maximum thickness of rocks of the proposed three restricted systems and of the series making up each period. The figures given are restricted to those obtainable from quite recent reports in order to insure that the correlations are comparable. Correlations are based in the main on the work of E. O. Ulrich and the late Charles D. Walcott. The figures are, in the main, from areas where the Ozark, with which we are primarily concerned, is supposed to be best developed.

The averages given may have no meaning but are of interest. Based on thickness of rocks only Lower Cambrian is of systemic order. But its fossils do not permit of close correlation for minor subdivisions, and its rocks as a rule do not lend themselves to minute subdivision and correlation.

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5 Logan, W. E., Geology of Canada: pp. 225-229, 1863.

6 Dana, J. D., Manual of Geology: p. 184, 1876.

THICKNESS OF EARLY PALEOZOIC ROCKS

LOCALITY	ORDOVICIAN				CANADIAN				CAMBRIAN			
	UPPER ORDOVICIAN CINCINNATI	MIDDLE ORDOVICIAN MOHAWK	LOWER ORDOVICIAN BLOUNT	ORDOVICIAN	UPPER CANADIAN CHAZY	MIDDLE CANADIAN BEEKMANTOWN	LOWER CANADIAN OZARK	CANADIAN	UPPER CAMBRIAN ST. CROIX	MIDDLE CAMBRIAN ACADIA	LOWER CAMBRIAN WAUCOBA	CAMBRIAN
	FEET	FEET	FEET	FEET	FEET	FEET	FEET	FEET	FEET	FEET	FEET	FEET
ALABAMA	100	500	800	1,400	650	1,500	5,700	7,850	1,900	4,000	6,700	12,600
TENNESSEE, ATHENS TROUGH	800	1,425	8,700	10,925	150	?	900	1,050+	1,080	700	4,550	6,330
TENNESSEE, KNOXVILLE TROUGH	1,500	1,700	2,800	6,000	1,000	2,000	1,000	4,000	1,080	700	4,550	6,330
TENNESSEE, WEST VALLEY	1,400	1,325	0	2,725	1,100	1,000	3,000	5,100	?	?	?	?
SOUTHWEST VIRGINIA	1,000	600	1,300	2,900	1,100	2,000	2,000	5,100	1,100	800	5,100	7,000
MIDWEST VIRGINIA	1,000	400?	1,000	2,400	175	1,500	2,000	3,675	0	900	5,800	6,700
NORTHWEST VIRGINIA	1,750	1,000	0	2,750	900	2,300	1,650	4,850	2,000	1,900	3,900	7,800
PENNSYLVANIA, CUMBERLAND VALLEY	2,000	500	0	2,500	1,250	2,300	1,635	5,185	2,000	2,000	5,750	9,750
PENNSYLVANIA, LANCASTER VALLEY						2,000	900	2,900+	500	0	5,100	5,600
PENNSYLVANIA, LEHIGH VALLEY	15,000?	600	0		0	1,500	1,500	3,000	0	0	1,400	1,400
NORTHEAST NEW YORK	600	1,100	1,000	2,700	800	1,500	900	3,200	0	0	1,540	1,540
INDIANA	440	625	0	1,065	120	400	430	950	1,790	?	?	?
MISSOURI, ROLLA AREA						1,160	950	2,110	850	0	0	850
UTAH									3,715	4,290	1,325	9,330
ARIZONA									1,200	0	0	1,200
SASKATCHEWAN									6,000	1,797	1,636+	9,433
ALBERTA, KICKING HORSE							6540	6,540	9,915	5,244	3,658	18,817
AVERAGE	1,500	880	1,400	3,780	660	1,590	2,070	3,960	2,200	1,500	3,400	7,100

A study of these figures from the general area of its supposed best development does not indicate that the Ozark is of higher stratigraphic order than that of the other series among which it is here placed. It is true that thickness of strata is only one element in judging the length of any period. The statement that of the 600 species in the Ozark fauna not a single one occurs in the rocks preceding or following, indicates that there has been a long time interval corresponding to which no rocks are known. How much time to allow for such a complete break in the life succession is quite uncertain, nor are we in position to determine what proportion of such time breaks before and after should be assigned to Ozark time, and what to the epochs immediately preceding and following. If we were to judge by the slowly changing life of the Tertiary, any stratigraphic break across which no forms of life pass must represent one, if not two full periods of time. To subdivide our time scale on that basis, however, would wipe out some of our present system boundaries and break up several of our systems into two or more systems each. While admitting the validity of the argument we are not prepared to make so radical an overhauling of our stratigraphic time chart as the use of such criteria would involve.

As a matter of practical experience probably nine-tenths of the problems that arise - in mapping, in drilling, in mining, in naming of rock beds - depend on the thickness, structure, and character of the rocks rather than on the fossil content. It would seem therefore that in any scheme of subdivision, character and thickness of rocks would play a major part. Thickness here implies body or extent as well as local thickness.

Not to prolong this discussion it is here proposed to divide the rocks of Lower Paleozoic age into three systems, to be limited as here shown:

Table of major division of Lower Paleozoic rocks.

Systems	Series	Limiting groups or beds*
Ordovician	Upper Ordovician or Cincinnati	T. Pulaski or Lower Maysville B. Utica
	Middle Ordovician or Mohawk	T. Trenton B. Lowville
	Lower Ordovician or Blount	T. Ottosoe B. Athens-Normanskill
Canadian	Upper Canadian or Chazy	T. Valcour-Holston B. Big Buffalo (Sneeds) member
	Middle Canadian or Beekmantown	T. Cassin-Bellefonte B. Tribes Hill (Sohaghticoke) member
	Lower Canadian or Ozark	T. Chepultepec B. Briarfield (Potsdam) member
Cambrian	Upper Cambrian or St. Croix	T. Nolichucky B. Rogersville
	Middle Cambrian or Acadia	T. Rutledge B. Rome-Watauga-Waynesboro
	Lower Cambrian or Wauooba	T. Shady-Tomstown B. Unicorn-Loudon-Hellam

*T top
B bottom.

Much more might be said. But if brevity is the soul of wit, it may be better to be witty than otherwise, and we have already set out without overmuch detail the causes that have led us to revive and adopt Canadian system for use by the Geological Survey of Pennsylvania.